

Reproductive Ecology and Vegetation Association Databases of Lake Ontario Fishes

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Abstract

An extensive literature review was carried out to compile information on the reproductive ecology of 42 Lake Ontario fishes that were rated medium to highly associated with lake habitat and spawned in the first two metres of water. Also, information was compiled on the vegetation association among various life stages of these fishes. The resulting databases of information will be used as part of a fish habitat/fisheries impact assessment model and, later, as part of a multi-factor model using links to Lake Ontario water level, bathymetry and vegetation patterns to determine potential for altering the water level-flow regime on the lake.

Several reproductive characteristics were considered and researched, with a variety of results in variables such as timing, duration, variation, and triggers of spawning, duration of egg incubation, post-hatch larval behaviour and reproductive guild.

Information gathered with respect to fish-vegetation association among these fishes included type of vegetation, strength of the association, seasonality differences, and factors affecting strength of the association.

The database indicated several areas where information was greatly lacking in our knowledge of the reproductive ecology and vegetation associations of these fishes. Precise calendar dates, duration and post-hatch behaviour of larvae were most notable, as well as vegetation association of juvenile fishes.

Résumé

Nous avons réalisé une vaste revue de littérature pour rassembler de l'information sur l'écologie reproductive de 42 poissons des lacs de l'Ontario qui ont été classés comme moyennement à fortement associés à l'habitat lacustre et qui frayaient dans les deux premiers mètres d'eau. De plus, de l'information a été compilée sur l'association avec la végétation à divers stades de la vie de ces poissons. Les bases de données ainsi établies serviront dans le cadre d'un modèle d'évaluation des impacts sur l'habitat du poisson et les pêches et, par la suite, d'un modèle multifacteurs comportant des liens avec le niveau de l'eau du lac Ontario, la bathymétrie et les peuplements végétaux afin de déterminer la possibilité de modifier le niveau de l'eau et le régime d'écoulement du lac.

Plusieurs traits reproductifs ont été retenus et examinés, ce qui a donné divers résultats pour des variables comme le calendrier, la durée, la variation et les éléments déclencheurs de la fraye, la durée de l'incubation des œufs, le comportement des larves après l'éclosion et la guilda de reproduction.

L'information recueillie en ce qui concerne l'association poissons-végétation portait sur le type de végétation, la solidité de l'association, les différences saisonnières et les facteurs qui influent sur la solidité de l'association.

La base de données a fait apparaître plusieurs domaines où notre information est très lacunaire en ce qui concerne l'écologie reproductive et les associations de ces poissons avec la végétation. Les lacunes apparaissaient surtout au sujet des calendriers précis, de la durée et du comportement des larves après l'éclosion, ainsi que de l'association avec la végétation chez les poissons juvéniles.

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1.0 Introduction

Information on the reproductive ecology and the vegetation association of various life stages of fish is necessary for the effective management of fish and their habitat. This knowledge is particularly important when assessing potential impacts on fish and their habitat resulting from external forces. One of these external forces may be changing water levels which could influence fish and their habitat by affecting nutrient concentrations, primary and secondary production, available prey items, accessibility to and amount of favourable spawning habitat and vegetative cover (Casselman and Lewis 1996).

As part of an International Joint Commission project on the potential for altering the water level-flow regime on Lake Ontario, a fish habitat/fisheries impact assessment model is being developed. To support the development of this model, a literature review was required of the reproductive ecology of some of the fishes occurring in Lake Ontario that may be affected by water level changes and of the associations between those fishes and vegetation assemblages.

The literature review was used to develop two databases, one on reproductive ecology and one on vegetation association. The information contained in the databases will be used, along with existing habitat requirements databases, to develop a guild-based impact assessment model which can be linked with models of water level, bathymetry, and vegetation patterns in Lake Ontario fish habitats. Incorporating all these models will produce an overall multi-factor assessment of alternate water level regulation schemes.

While the information contained in the database is useful for developing models and certain conclusions can be made, it is important to note there are limitations. Due to the lack of specific information on the fishes of Lake Ontario, much of the data compiled in the databases was supplemented by studies from similar geographic areas to Lake Ontario. The authors also acknowledge that information on the reproductive ecology and vegetation association of Lake Ontario fishes may exist in "grey" literature, especially in the latter in unpublished field records. However, information of this type are difficult to track down as they rarely occur in standard abstracts. No efficient way of compiling and locating this material has been developed. Lastly, the assessment of the rating for the

vegetation association database was subjective, following definitions laid out by Lane *et al.* (1996a).

This report presents a summary of the databases of the reproductive ecology and the vegetation association of some Lake Ontario fishes.

2.0 Methods

To determine the species to be included in the reproductive ecology and vegetation association databases, species reported to be established in Lake Ontario were first compiled using Cudmore-Vokey and Crossman (2000). Only those species with established populations were included, therefore species extirpated from the Great Lakes (i.e. bloater (*Coregonus hoyi*)) and species found in, but don't spawn in, the Great Lakes were excluded (i.e. American eel (*Anguilla rostrata*)) (Lane *et al.* 1996a, Cudmore-Vokey and Crossman 2000). From this list, species given an affinity rating of low for lake habitat according to Lane *et al.* (1996a) were eliminated. Next, only species reported to be restricted to the first two metres of water for spawning (Lane *et al.* 1996a) were kept.

An extensive literature search was executed using the Aquatic Sciences and Fisheries Abstracts (ASFA) database to obtain information on the reproductive ecology and fish-vegetation associations for the final compilation of species. The primary source of information was literature published from 1978 to present. For secondary sources of information, reference volumes containing summaries of species were used (Scott and Crossman 1973, Becker 1983), including one government publication (Meisenheimer 1988).

2.1 Reproductive Ecology Database

Several spawning characteristics were researched to develop a better understanding of the reproductive ecology of the species found in this database. Where information specifically for Lake Ontario was not found, information for populations as close geographically to Lake Ontario as possible was used. In many cases this information was based on Great Lakes' or provincial populations, but in others, information was based on the only available knowledge, either other Canadian or

northern American populations. Where possible, the location is indicated in the database. Where there was no information found for a specific spawning characteristic of a species, the area was left blank.

The spawning characteristics found in the reproductive ecology database are more fully described below:

- i) Time of spawning - the precise time of spawning (preferably in calendar dates for in Lake Ontario) is listed.
- ii) Duration - the duration of the spawning season in days.
- iii) Secular variation with respect to environmental variables - any evidence of secular variation of spawning as it relates to environmental variables was included here.
- iv) Triggers - these would include such factors as light, changing temperatures or water levels.
- v) Spawning temperature range - included for most species was a range of temperatures (in °C) above and below which spawning will not take place.
- vi) Duration of egg incubation - the length of time required for egg incubation was included along with factors such as temperature or inundation which would affect duration or success of the incubation.
- vii) Immediate post-hatch behaviour of larvae - any information on the activities of the larvae following hatching, such as movement, position or feeding, including typical duration of the behaviour, was included here.
- viii) Reproductive guild and additional information - Balon classification of reproductive guild (as found in Lane *et al.* (1996a)) and any additional details regarding spawning and egg laying behaviour or physical description of eggs were detailed here.

2.2 Vegetation Association Database

Information was gathered with respect to the relationship those fishes listed in this database had to vegetation at all life stages (spawn/egg, young-of-the-year, juvenile, and adult). Variables of interest were:

- i) Vegetation - the type of vegetation, preferably to species, associated with a particular species at a particular life stage.
- ii) Strength - the strength of the association between the fish species and vegetation was based on the following ratings: nil (association of no importance), low (sometimes associated), medium (often associated), and high (always or nearly always associated). Where there is no rating, no information could be found to indicate strength of association.
- iii) Seasonality differences - any changes of the type of vegetation a fish species is normally associated with due to changes in the season.
- iv) Factors affecting strength - any variables which change the strength of the fish-vegetation association, such as vegetation density.

Literature citations found in the databases were numbered and combined with citations from the text and are found in the References section of this report.

3.0 Results and Discussion

A total of 42 species are found to occur in Lake Ontario which have a medium or high affinity for lake habitat and also are restricted to the first two metres of water for spawning. A complete list of the species in the databases is found in Table 1, using common and scientific names and order generally following Robbins *et al.* (1991).

3.1 Reproductive Ecology Database

The following results refer to information contained in Table 2.

Ninety-eight percent of the species listed in this database spawn in the spring. One species, redfin shiner, spawns in summer during the months of July and August and one species, grass pickerel, experiences low intensity spawning in the fall as well as spawning in the spring.

Of the 42 species listed, information on some aspect of the duration of spawning was found for 15 species. Of these, about six species have a spawning duration of more than ten days and about five species have a duration of less than ten days.

A variety of information on the secular variation with respect to environmental variables was found for 16 species. The information ranged from timing of spawning being affected by variables such as spawning of other species, time of day, and presence of favourable or unfavourable vegetation. Three species were influenced by water levels.

Information on factors that trigger spawning was found for 29 species. Of these, the spawning of 28 species was influenced solely (22) or in combination (6) by a rise in or a change in temperature. Of these 28 species, five were also influenced by photoperiod, and the spawning one species was also influenced by increasing oxygen levels. One species, central mudminnow, was influenced by rising water levels, which would flood adjacent lands creating suitable spawning habitat. The only information on what factor triggers spawning in redfin shiner was the spawning of green sunfish (information from Wisconsin) (Scott and Crossman 1973, Becker 1983, Noltie 1989, Lane *et al.* 1996).

Details on the temperature range in which spawning occurs was found for 32 species, although optimum temperatures were given for an additional five species. Eighteen species had a wide temperature range of 10 or more degrees apart, while the temperature range for fourteen species was a difference of less than 10 degrees.

Data on the duration of egg incubation was provided for 31 species. It is difficult to draw any comparisons from the dataset as the duration was highly dependent on a wide range of temperatures from both field and aquaria studies.

The behaviour of post-hatch larvae was provided for 22 species. Seventeen of these species remain relatively inactive near spawning site for several days post-hatch. Eight species attach to vegetation and four species are guarded by males. Information for five species state that they begin to actively feed within ten days. Five species (finescale dace, brook silverside, rock bass, banded killifish, and logperch) move from spawning site within a few days of hatching.

All species (42) in the database were placed in a reproductive guild using the Balon classification (from Lane *et al.* 1996a). Most species (59.5%) were in the broadcast category, 31% were in the nest category, 7.1% were in the hide category and 2.4% (one species, pirate perch) was categorized as being an external brooder (gill

cavities). The eggs of 24 species are adhesive and 29 species use cover, such as aquatic vegetation, banks, or under rocks, during spawning.

3.2 Vegetation Association Database

The following results refer to information contained in Tables 3 to 44.

Much of the information found on the vegetation type which these fish species associate with was general, with words such as submergent, macrophytes, grasses, algae. More specific information was given where possible, such as a species name (e.g. *Potamogeton* spp), or common name (e.g. water lilies).

Of the 42 species in the database, information was found (general and specific) for at least one life stage for 39 species. Of the remaining three species, lake chub had no association with vegetation during any of its life stages, blacknose dace had no association during the spawn/egg and adult life stages (no information was found concerning vegetation association for the YOY or juvenile life stages), and pirate perch had no association during the spawn/egg life stage, although was highly associated with vegetation as an adult but no information was found with respect to type of vegetation as well as for the YOY or juvenile life stages. For twelve of the 39 species, information (general and specific) on vegetation type was found for all life stages. Northern pike was the only species in the database for which specific information on vegetation association could be found for all four life stages.

By breaking down information by life stage, it became clear that specific information was less available for YOY (one entry) and for juveniles (two entries). Four entries had specific information for the spawning life stage and eight entries for the adult stage.

Looking at general information, it was interesting that more information was available for YOYs (33 species), followed by the spawning life stage (29 species), and adults (26 species). Only 12 species had general information listed in the database for the juvenile life stage. Casselman and Lewis (1996) also noted this discrepancy in the level of information in the literature for various life stages.

As for the rating of the strength of the fish-vegetation association, it was found that for most species, the four life stages were given a rating of high (22 high ratings for spawning/egg, 24 for YOY, 16 for juveniles, and 27 for the adult life stage) (Figure 1).

Ten species could be considered highly associated with vegetation throughout their entire life history. These species are: longnose gar, common carp, golden shiner, yellow bullhead, grass pickerel, northern pike, banded killifish, green sunfish, pumpkinseed, and least darter. However, an additional seven species (spotted gar, bowfin, pugnose shiner, blackchin shiner, blacknose shiner, muskellunge, and central mudminnow) had a rating of high for all life stages except juvenile. Given the lack of information regarding the juvenile life stage with respect to vegetation associations, these additional seven species could also be considered highly associated with vegetation at all life stages.

Very few species experience differences in their vegetation association due to seasonal changes. No information was found on seasonality differences for any species during the spawning/egg life stage. Three species alter the vegetation association in the YOY life stage. Modification to the vegetation association during the juvenile life stage for eight species was recorded in the database. All of these modification were due to seasonal growth of macrophytes. Two species in the adult stage altered their association, one (brassy minnow) became more associated during the late summer months and the other (central mudminnow) was more associated with inundated terrestrial vegetation during the spring, changing to aquatic macrophytes in the summer and to leaf litter in the autumn.

Factors that can affect the strength of the fish-vegetation association were varied. Vegetation density was the factor that affected more species (entered six times in database), mostly in the adult stage. Preference for dense vegetation cover accounted for half of the entries and the other half was for a preference of moderate cover. Habitat characteristics also accounted for changes in vegetation association. Two species (fathead minnow and smallmouth bass) preferred to spawn in non-vegetated areas and will chose this habitat over vegetated areas. Largemouth bass prefer emergent to submergent vegetation during the spawn/egg life stage. Adult central mudminnows will avoid current, decreasing the strength of the vegetation association in vegetated areas

with current. Three entries indicated that food was a factor in the strength of the fish-vegetation association. The greater the amount of food items available among macrophytes, the greater the strength of the association. Size of the fish was a factor for the association between YOY northern pike and adult muskellunge and vegetation. The larger the fish, the less strongly associated they were with vegetation. Adult male northern pike were also more strongly associated with *Potamogeton* sp. than adult female northern pike.

4.0 Summary and Conclusions

The information contained in this report describes the reproductive ecology and vegetation association databases. It serves as a compilation of the knowledge concerning a variety of characteristics of reproductive ecology of some Lake Ontario fishes and illustrates the importance of vegetation to these fishes at all life stages.

It became evident during the research for the databases that a lot of information on several aspects of the reproductive ecology and vegetation association is not available for many species and life stages. Most notably absent in the reproductive ecology database was information on precise calendar dating of spawning times, duration of spawning, and the immediate post-hatch behaviour of larvae. Perhaps more surprising was the lack of information in the vegetation database, particularly the juvenile life stage, which has also been noted by Lane *et al.* (1996b) and Casselman and Lewis (1996). Clearly, there is a need to acquire this information and future research should be aimed at filling these data gaps.

However, the data contained in this report can be useful in identifying the reproductive characteristics of Lake Ontario fishes and the association these fishes have to vegetation. The data can further be used to develop an impact assessment model to determine the potential for altering water level-flow regimes on Lake Ontario.

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6.0 References

1. Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison, Wisconsin. 1052pp.
2. Bryan, M.D. and D.L. Scarnecchia. 1992. Species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of a glacial Iowa lake. *Environ. Biol. Fishes.* 35:329-341.
3. Burr, B.M. and L.M. Page. 1979. The life history of the least darter, *Etheostoma microperca*, in the Iroquois River, Illinois. Biological Notes No. 112. Illinois Institute of Natural Resources and Illinois Natural History Survey. 15pp.
4. Campbell, R. R. 1994. Updated status report on the spotted gar, *Lepisosteus oculatus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. 13 pp.
5. Casselman, J. M. and C.A. Lewis. 1996. Habitat requirements of northern pike (*Esox lucius*). *Can. J. Fish. Aquat. Sci.* 53(Suppl.1):161-174.
6. Curry, K.D. and A. Spacie. 1984. Differential use of stream habitat by spawning Catostomids. *Am. Mid. Nat.* 111(2):267-279.
7. Cudmore-Vokey, B. and E.J. Crossman. 2000. Checklists of the fish fauna of the Laurentian Great Lakes and their connecting channels. *Can. MS Rpt. Fish. Aquat. Sci.* 2550:v+39p.
8. Dalton, K.W. 1990. The status of the least darter, *Etheostoma microperca*, in Canada. *Can. Field-Nat.* 104(1):53-58.
9. Das, M.K. and J.S. Nelson. 1990. Spawning time and fecundity of northern redbelly dace, *Phoxinus eos*, finescale dace, *Phoxinus neogaeus*, and their hybrids in Upper Pierre Grey Lake, Alberta. *Can. Field-Nat.* 104:409-413.
10. de Vlaming, V.L. and J. Shing. 1977. Effects of long-term exposure to constant photoperiod-temperature regimes on gonadal activity and energy reserves in the golden shiner, *Notemigonus crysoleucas*. *Copeia.* 1977:774-777.
11. Fontenot, Q.C. and D.A. Rutherford. 1999. Observations on the reproductive ecology of pirate perch *Aphredoderus sayanus*. *J. Freshwat. Ecol.* 14:545-549.
12. Gale, W.F. and C.A. Gale. 1977. Spawning habits of spotfin shiner (*Notropis spilopterus*) – a fractional, crevice spawner. *Trans. Am. Soc.* 106:170-177.
13. Gale, W.F. and G.L. Buynak. 1982. Fecundity and spawning frequency of the fathead minnow – a fractional spawner. *Trans. Am. Soc.* 111:35-40.
14. Gee, M. 1986. The population biology of *Culaea inconstans*, the brook stickleback, in a small prairie lake. *Can. J. Zool.* 64:1709-1717.
15. Goodchild, C.D. 1990. The status of the brook silverside, *Labidesthes sicculus*, in Canada. *Can. Field-Nat.* 104(1):36-44.
16. Holm, E., P. Dumont, J. Leclerc, G. Roy and E. J. Crossman. 1999. COSEWIC Status Report on the bridge shiner, *Notropis bifrenatus*. Committee on the Status of Endangered Wildlife in Canada. 21 pp.
17. Houston, J. J. P. 1990. The status of the banded killifish, *Fundulus diaphanus*, in Canada. *Can. Field-Nat.* 104(1):45-52.
18. Johnson, B.L. and D.B. Noltie. 1996. Migratory dynamics of stream-spawning longnose gar (*Lepisosteus osseus*). *Ecol. Freshwat. Fish.* 5:97-107.
19. LaChance, S., P. Magnan, and G.J. FitzGerald. 1987. Temperature preferences of three sympatric sticklebacks (Gasterosteidae). *Can. J. Zool.* 65:1573-1576.
20. Lane, J.A., C.B. Portt, and C.K. Minns. 1996a. Spawning habitat characteristics of Great Lakes fishes. *Can. MS Rpt. Fish. Aquat. Sci.* 2368:v+48pp.
21. Lane, J.A., C.B. Portt, and C.K. Minns. 1996b. Nursery habitat characteristics of Great Lakes fishes. *Can. MS Rpt. Fish. Aquat. Sci.* 2338:v+42pp.
22. Lane, J.A., C.B. Portt, and C.K. Minns. 1996c. Adult habitat characteristics of Great Lakes fishes. *Can. MS Rpt. Fish. Aquat. Sci.* 2358:v+43pp.
23. Mandrak, Nicholas E. and E. J. Crossman. 1996. The status of the lake chubsucker, *Erimyzon sucetta*, in Canada. *Can. Field-Nat.* 110(3):478-482.
24. Martin-Bergmann, K.A. and J.H. Gee. 1985. The central mudminnow, *Umbra limi* (Kirtland), a habitat specialist and resource generalist. *Can. J. Zool.* 63:1753-1764.
25. Meisenheimer, P. 1988. Descriptions of critical fish habitat for species in the area of the undertaking. Prepared for Fish Community and Habitat Section, Fisheries Branch, Ontario Ministry of Natural Resources. 143pp.
26. Meredith, G.N. and J.J. Houston. 1988. The status of the green sunfish, *Lepomis cyanellus*, in Canada. *Can. Field-Nat.* 102(2):270-276.
27. Ming, F.W. and D.L.G. Noakes. 1984. Spawning site selection and competition in minnows (*Pimephales notatus* and *P. promelas*) (Pisces, Cyprinidae). *Biol. Behav.* 9:227-234.

28. Moodie, G.E.E. 1986. The population biology of *Culaea inconstans*, the brook stickleback, in a small prairie lake. *Can. J. Zool.* 64:1709-1717.
29. Noltie, D.B. and M.H.A. Keenleyside. 1987. Breeding ecology, nest characteristics, and nest-site selection of stream- and lake-dwelling rock bass, *Ambloplites rupestris* (Rafinesque). *Can. J. Zool.* 65:379-390.
30. Noltie, D.B. 1989. Status of the redfin shiner, *Notropis umbratilis*, in Canada. *Can. Field-Nat.* 103(2):201-215.
31. Page, L.M. and C.E. Johnston. 1990. Spawning in the creek chubsucker, *Erimyzon oblongus*, with a review of spawning behavior in suckers (Catostomidae). *Environ. Biol. Fishes.* 37:265-272.
32. Parker, B.R. and W.G. Franzin. 1991. Reproductive biology of the quillback, *Carpionodes cyprinus*, in a small prairie river. *Can. J. Zool.* 69:2133-2139.
33. Parker, B. and P. McKee. 1983. Status report on the spotted gar, *Lepisosteus oculatus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. 15 pp.
34. Parker, B., P. McKee and R. R. Campbell. 1987. The status of the pugnose shiner, *Notropis anogenus*, in Canada. *Can. Field-Nat.* 101(2):203-207.
35. Powles, P.M., S. Finucan, M. van Haften, and R. A. Curry. 1992. Preliminary evidence for fractional spawning by the northern redbelly dace, *Phoxinus eos*. *Can. Field-Nat.* 106:237-240.
36. Robbins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea and W.B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. Fifth edition. *Am. Fish. Soc. Spec. Publ.* 20. Bethesda, Maryland. 183p.
37. Savino, J.F. and R.A. Stein. 1989. Behavior of fish predators and their prey: habitat choice between open water and dense vegetation. *Environ. Biol. Fishes.* 24:287-293.
38. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184.
39. Skov, C. and S. Berg. 1999. Utilization of natural and artificial habitats by YOY pike in a biomanipulated lake. *Hydrobiol.* 408/409:115-122.
40. Storr, J. F., P.J. Hadden-Carter, J.M. Myers, and A.G. Smythe. 1983. Dispersion of rock bass along the south shore of Lake Ontario. *Trans. Am. Fish. Soc.* 112:618-628.

41. Trautman, M.B. 1981. The fishes of Ohio. Revised edition. Ohio State University Press. Columbus, Ohio.
42. Weaver, M.J. and J.J. A. Magnuson, and M.K. Clayton. 1997. Distribution of littoral fishes in structurally complex macrophytes. *Can. J. Fish. Aquat. Sci.* 54:2277-2289.
43. Wootton, R.J. 1973. Fecundity of the three-spined stickleback, *Gasterosteus aculeatus* (L.). *J. Fish. Biol.* 5:683-688.

Table 1. Species found in the reproductive ecology and vegetation association databases.

LEPISOSTEIDAE

- Lepisosteus oculatus* (spotted gar)
- Lepisosteus osseus* (longnose gar)

AMIIDAE

- Amia calva* (bowfin)

CYPRINIDAE

- Couesius plumbeus* (lake chub)
- Cyprinella spiloptera* (spotfin shiner)
- Cyprinus carpio* (common carp)
- Hybognathus hankinsoni* (brassy minnow)
- Lythrurus umbratilis* (redfin shiner)
- Notemigonus crysoleucas* (golden shiner)
- Notropis anogenus* (pugnose shiner)
- Notropis bifrenatus* (bridle shiner)
- Notropis heterodon* (blackchin shiner)
- Notropis heterolepis* (blacknose shiner)
- Notropis ludibundus* (sand shiner)
- Phoxinus phoxinus* (northern redbelly dace)
- Phoxinus neogaeus* (finescale dace)
- Pimephales promelas* (fathead minnow)
- Rhinichthys atratulus* (blacknose dace)

CATOSTOMIDAE

- Carpodes cyprinus* (quillback)
- Catostomus commersoni* (white sucker)

ICTALURIDAE

- Ameiurus natalis* (yellow bullhead)
- Ameiurus nebulosus* (brown bullhead)
- Noturus flavus* (stonecat)
- Noturus gyrinus* (tadpole madtom)

ESOCIDAE

- Esox americanus vermiculatus* (grass pickerel)
- Esox lucius* (northern pike)
- Esox masquinongy* (muskellunge)

UMBRIDAE

- Umbra limi* (central mudminnow)

APHREDODERIDAE

- Aphredoderus sayanus* (pirate perch)

ATHERINIDAE

- Labidesthes sicculus* (brook silverside)

FUNDULIDAE

- Fundulus diaphanus* (banded killifish)

GASTEROSTEIDAE

- Culaea inconstans* (brook stickleback)
- Gasterosteus aculeatus* (threespine stickleback)

CENTRARCHIDAE

- Ambloplites rupestris* (rock bass)
- Lepomis cyanellus* (green sunfish)
- Lepomis gibbosus* (pumpkinseed)
- Micropterus dolomieu* (smallmouth bass)
- Micropterus salmoides* (largemouth bass)

PERCIDAE

- Etheostoma exile* (Iowa darter)
- Etheostoma microperca* (least darter)
- Etheostoma nigrum* (johnny darter)
- Percina caprodes* (logperch)

Table 2. Reproductive ecology database of selected Lake Ontario fishes.

Taxon	Time of Spawning	Duration (days)	Secular Variation with respect to Environmental Variables	Triggers	Spawning Temp. Range (°C)	Duration of Egg Incubation	Immediate Post-Hatch Behaviour of Larvae	Reproductive Guild and Other Information	Sources
Spotted gar	spring				21-26	hatch within a week	cling to aquatic plants and debris or hang from surface film by their disc-like jaws	broadcast, eggs adhere to vegetation, uses abundant vegetation, brush and debris	38, 33, 4, 20
Longnose gar	late spring-early summer; June (Georgian Bay)	3 day periods separated by a week or more during breeding season			19-29	3-9d (Wisconsin)	adhere to vegetation vertically by tip of snout, about 9d after hatching yolk is absorbed and they cease to hang vertically and begin to hold position horizontally in water column	broadcast, eggs scatter randomly and adhere to vegetation (especially <i>Cladophora</i>)	38, 1, 25, 18, 20
Bowfin	spring; May 24-June 1 (Georgian Bay)			temp-nest construction and spawning	16-19	8-10d	attach to vegetation by tip of snout or lie on their sides in the bottom of the nest for 7-9d (or until 12mm)	broadcast, adhesive eggs, nests built on bottom often under logs, stumps or brush	38, 1, 25, 20

Lake chub	spring, late April and May				above 15	10d at 8-19C		broadcast, spawns under boulders	38, 1, 25, 20
Spotfin shiner	spring; late May to mid-August (New York)	generally 5 day intervals	fractional spawners, spawning site depends on current strength, depth, and availability of underwater objects (crevices)	temp; 18-29		5-5d at 22C		hide, adhesive eggs on undersides of fixed objects (logs and roots)	38, 12, 1, 25, 20
Common carp	spring, late May or early June (Wisconsin)	intermittent spawning of several days to several weeks		temp	17-28	3-16d (3-5d at 20C; 5d at 15C)	typically found on bottom in vegetation	broadcast, randomly deposited eggs adhere to vegetation	38, 1, 25, 20
Brassy minnow	spring; May or June	7-10d at 16-27C			10-13			broadcast	38, 1, 25, 20
Redfin shiner	July and August			spawning of green sunfish (Wisconsin)	21			broadcast, utilizes sunfish nests	38, 1, 30, 20,
Golden shiner	spring; early June (June 11, Gananoque River; May to August in NEW YORK)	4-5 distinct peaks during spawning period	vegetation is essential to spawning	temperature 20C, photoperiod	20-27	4d at 23.9-26.7C		broadcast, eggs adhere to vegetation, organic debris and filamentous algae	38, 10, 1, 25, 20,
Pugnose shiner	late spring; early to mid-June				21-29			broadcast	38, 1, 34, 20
Bridle shiner	late spring; early May-mid Aug		European watermilfoil creates unsuitable	temp 14-27	14-26		hatched embryos remain on bottom	broadcast on vegetation	38, 25, 20, 16

				spawning habitat by reducing the clear area of water above plants.					within weed beds, but soon move to shallow open water over barren bottoms		
Blackchin shiner	spring; May-June (Illinois), June-August (Wisconsin)									broadcast	38, 1, 25, 20,
Blacknose shiner	spring; July 26 (Niagara River, New York)									broadcast, uses roots of aquatic vegetation as cover	38, 25, 20
Sand shiner	spring; late May to mid- August (Wisconsin)					21				broadcast, adhesive eggs on roots of aquatic vegetation	38, 1, 25, 20,
Northern redbelly dace	spring or early summer, June to July (Ontario)	38d (Alberta)			13-18C spawning time	21-27	8-10d (at 21.1- 26.7C)			broadcast over mats of filamentous algae, possible fractional spawner	38, 1, 25, 9, 35, 20,
Finescale dace	spring; April to June (Wisconsin)	38d (Alberta)			possibly sudden rise and considerable fluctuation in water temperature after ice disappears	11-18	4d	swimming 3 days after hatching, actively feeding after 7d		broadcast, associated with logs and brush	38, 1, 25, 9, 20,

Fathead minnow	spring; late May or early June to mid August (Wisconsin)	spawn 16-26 times during spawning period		temperature or photoperiod or both	16-29	4.5-6d at 25C	remain near the nest until yolk sac is absorbed	nest, adhesive eggs found on the undersides of fixed objects(log, branch, rock), rarely under lily pads	38, 13, 1, 27, 25, 35, 20,
Blacknose dace	spring; May or June to early July (Wisconsin)		fast flowing shallow waters	temp - 21.1C or photoperiod	12-27			hide	38, 1, 25, 20,
Quillback	spring; April or May (Minnesota)		spawning takes place after white suckers (Indiana)	temperature	7-28	11-18d at 16C		broadcast, spawns in areas with high turbidity	38, 6, 25, 32, 20
White sucker	spring; early May to early June		spawning usually takes place at dusk and dawn, peaking in intensity between 2200 and 2300hr	Water temperature (10C) may be an important factor in determining peak and duration of spawning migration.	6-23	14d (8-11d at 10-15C), 5-7d at 13.9-20C	remain in gravel 7- 14d (12-14mm TL) then move downstream at night	broadcast, eggs adhere to substrate	38, 1, 6, 25, 31, 20,
Yellow bullhead	spring; late May to early June					5-10d	guarded until 50mm long	nest, near logs, tree roots, boards, debris, under tree bank	38, 1, 25, 20,
Brown bullhead	spring; May or June		water can be as shallow as 15cm or as	temp(21.1C)	14-29	6-9d at 20.6- 23.3C	yolk sac too large to enable them to	nest, adhesive eggs, near logs,	38, 1, 25, 20,

						deep as several feet, spawn early morning to 1400hr					swim, lie on their sides in nest until about the seventh day. Then begin to swim and feed actively	tree roots, boards, debris, inside hollow stumps, tires	
Stonecat		spring summer up to as late as August peak commences in June or July						temp (27.8C)	25			nest, under boards, rocks, logs	38, 1, 25, 20,
Tadpole madtom		spring summer, late June or July										nest, eggs adhere to one another under boards, roots, logs, in dark cavities including discarded cans	38, 25, 20
Grass pickerel		spring, late March to early May, but low intensity spawning in fall				movement to spawning areas after ice is gone		temp (change not increase)	4.4-12	11-15d at 7.8- 8.9C	inactive near bottom possibly attached to vegetation living off yolk for 10-14d	broadcast, slightly adhesive eggs amongst flooded terrestrial vegetation	38, 1, 25, 20
Northern pike		spring, April to early May	commence April 11, peak April 18, ended April 20 in Lake Simcoe			spawns in daylight hours, high water levels at time of spawning and stable levels after incubation associated with large year-classes	immediately after ice melt (4.4-11.1C)		2-18	12-14d	remain inactive attached to vegetation by means of adhesive glands on head for 6-10d feeding on yolk. Begin to feed after	broadcast, adhesive eggs amongst flooded terrestrial vegetation	38, 1, 25, 5, 20

Muskellunge	spring, late April to early May			spawning in water 15- 28cm deep, 1900- 0300hr	combination of factors: temperature, increasing photoperiod, increasing oxygen levels	8-18, optimal temp 12.8C	8-14d at 11.7- 17.2C	10d (11-12mm), highly dependent on plankton pulses.	broadcast, amongst stumps and logs	38, 1, 25, 20,
Central mudminnow	early spring: mid to late April	in favourable conditions, spawning can be completed within several days Breeding season can be extended with unfavourable conditions	high water levels and low temperatures can negatively affect spawning		rise in water temp and flooding of adjacent areas (suitable breeding habitat)	~13	6d		broadcast, adhesive eggs	38, 1, 24, 25, 20,
Pirate perch	spring, May (Wisconsin)						5-6d at 19-20C		external brooder (gill cavities), adhesive eggs	1, 11
Brook silverside	spring, May to July (SE Michigan), May (peaking June and July) to early August (Wisconsin)	protracted: 41d (June) in Lake Opinicon, Ont.			temperature: pairing at 18C, spawning at 20C, peak spawning at 22.7C	20-23	8-9d at 22.8- 24C	wiggle to surface and assemble into schools of 30-200 individuals. Confine themselves to upper 3 cm below surface, constantly active,	broadcast, eggs attaches to vegetation by adhesive filaments	38, 1, 25, 15, 20,

Banded killifish	spring, April and May (Newfoundland), June to mid August (Wisconsin)				highly dependent on water temperature	21-32	11-12d at 22.2-26.7C	found in weedy shallows	broadcast, eggs adhere to vegetation	38, 25, 17, 20
Brook stickleback	spring, late April to July	28d (Manitoba)			requires vegetation for nest construction and clear water for courtship displays	8-19	8-9d at 18.3C	attach to (or remain still among) nest materials for several days, male parent constructs nursery from nest where young are kept for 1-2 more days	nest, under sticks	38, 1, 14, 28, 25, 20,
Threespine stickleback	spring, June or July	spawn several times during breeding season			temperature	10-23	7d at 19C		nest, eggs adhere to one another in clusters	38, 43, 19, 25, 20
Rock bass	spring, May-July				temp (15.6-21.1)	14-24	3-4d in aquaria at 20.5-21C	rise up out of nest within a few days	nest, adhesive eggs under rocks and logs	20, 38, 1, 40, 29, 25
Green sunfish	spring, mid-May to early August (Wisconsin)	every 8 or 9d, each spawning took place over a period of 1 or 2d			temperatures greater than 15C and long photoperiods (15hr or longer)	15-28	3-5d	yolk absorbed and swim up observed by 145hr after hatching, feeding after 5d	nest, adhesive eggs under rocks and logs and near clumps of grass	38, 1, 25, 20,
Pumpkinseed	spring (into August in				temp (20C)	13-29	3d at 28C	stay in nest for first 11d	nest in depths of 6-12 inches	38, 1, 25, 26, 20,

	June			to early evening; loggerch may leave breeding area if there is a change in climatic conditions				areas, have been collected in open waters	eggs	
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Table 3. Vegetation association database - spotted gar.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		sub/emerg	20;21;22
Strength of Association	high	high		high	38;20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 4. Vegetation association database - longnose gar.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg, grasses	submerg	macro- phytes	submerg	1;2;20;21;22
Strength of Association	high	high	high	high	38;1;25;2;20;21
Seasonality Differences			seasonal growth of macro- phytes		2
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 5. Vegetation association database - bowfin.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	submerg		submerg	1;20;21;22
Strength of Association	high	high		high	38;1;25;20;21
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 6. Vegetation association database – lake chub.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation					
Strength of Association	nil	nil	nil	nil	38;1;25; 20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 7. Vegetation association database – spotfin shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	submerg	macro- phytes		2;20;21
Strength of Association	low	low	high	low	38;1;25;2;20;21; 22
Seasonality Differences			seasonal growth of macro- phytes		2;20;21
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 8. Vegetation association database – common carp.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		sub/emerg	20;21;22
Strength of Association	high	high	high	high	38;1;25;20;21; 22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 9. Vegetation association database – brassy minnow.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg			20,21
Strength of Association ¹	high	medium		high	1,25,20,21
Seasonality Differences				late summer	25
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 10. Vegetation association database – redfin shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation		sub/emerg		sub/emerg	21,22
Strength of Association ¹		high		high	38,21,22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 11. Vegetation association database – redfin shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg, filamentous algae	sub/emerg		sub/emerg	25,20,21,22
Strength of Association ¹	high	high	high	high	38,1,25,20,21,22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 12. Vegetation association database – pugnose shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		pondweed species, water milfoil, <i>Elodea</i> , eel grass, coontail, bullrush, <i>Chara</i> , filamentous algae (especially <i>Spirogyra</i>)	1;20;21;22
Strength of Association	high	high		high	1;34;20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 13. Vegetation association database – bridle shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg, <i>Myriophyllum</i> , <i>Chara</i>	submerg		submerg	38;25;20;21;22
Strength of Association	high	medium		high	38;25;20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 14. Vegetation association database – blackchin shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	submerg		submerg	20;21;22
Strength of Association	high	high		high	38;1;25;20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 15. Vegetation association database – blacknose shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		filamentous algae, bulrushes, wild rice, waterweed, pondweed, arrowhead	1;20;21;22
Strength of Association¹	high	high		high	38;1;25;20;21; 22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 16. Vegetation association database – sand shiner.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		rooted veg	38;25;20;21;22
Strength of Association¹	low	medium		low	38;1;25;20;21;22
Seasonality Differences					
Factors Affecting Strength				density - prefers sparse	38

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 17. Vegetation association database – northern redbelly dace.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	submerg, filamentous algae			sub/emerg	38;25;22
Strength of Association¹	high			high	38;1;25;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 18. Vegetation association database – finescale dace.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation				sub/emerg	22
Strength of Association¹				high	22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 19. Vegetation association database – fathead minnow.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg		floating submerg (algae), some rooted	1;20;21;22
Strength of Association¹	medium	medium		medium	38;1;27;37;20;21
Seasonality Differences					
Factors Affecting Strength	prefers non- vegetated surfaces for spawning site				38

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 20. Vegetation association database – blacknose dace.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation					
Strength of Association¹	nil			nil	38;1
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 21. Vegetation association database – quillback.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation		submerg		submerg	21;22
Strength of Association¹	nil	medium		low	38;1;25;32
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 22. Vegetation association database – white sucker.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	submerg	pondweed, rushes among <i>Potamogeton</i>	emerg	25;20;21;22
Strength of Association¹	low	high	high	medium	38;1;25;20;21; 22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 23. Vegetation association database – yellow bullhead.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	sub/emerg	macro- phytes	sub/emerg	2;20;21;22
Strength of Association¹	high	high	high	high	38;1;25;2;20; 21;22
Seasonality Differences			seasonal growth of macro- phytes		2;20;22
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 24. Vegetation association database – brown bullhead.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	sub/emerg macro- phytes	macro- phytes	sub/emerg macro- phytes	20;21;22;42
Strength of Association	medium	high	high	high	38;1;25;20;21;22; 42
Seasonality Differences					
Factors Affecting Strength		possibly attracted by aggre- gations of food items in macro- phytes	possibly attracted by aggre- gations of food items in macro- phytes	possibly attracted by aggre- gations of food items in macro- phytes	20;21;42

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 25. Vegetation association database – stonecat.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation		sub/emerg			20
Strength of Association	nil	low		nil	38;1;20
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 26. Vegetation association database – tadpole madtom.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	roots of vegetation	sub/emerg		sub/emerg	1;20;21;22
Strength of Association	medium	high		high	38;1;25;20;21; 22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 27. Vegetation association database – grass pickerel.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	sub/emerg	grasses	leafy liverworts, water lilies, pondweeds, filamentous algae, broadleaf cattails	1;25;20;21;22
Strength of Association ¹	high	high	high	high	38;1;25;20;21; 22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 28. Vegetation association database – northern pike.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	<i>Carex</i> spp., <i>Calamagrostis canadensis</i>	<i>Phragmites australis</i> , <i>Typha</i> spp., <i>Myriophyllum</i> , <i>Potamogeton</i>	<i>Potamogeton crispus</i> , <i>Ceratophyllum demersum</i> and <i>Elodea canadensis</i>	<i>Potamogeton crispus</i> , <i>Ceratophyllum demersum</i> and <i>Elodea canadensis</i>	2;5
Strength of Association	high	high	high	high	38;1;25;37; 2; 5;20;21;22; 39
Seasonality Differences		strength of assoc grew over summer	seasonal growth of macrophytes		2;5
Factors Affecting Strength		size of pike inversely related to veg density, related to cover	prefer moderately dense macrophytes (between 30-80% vegetative cover)	prefer moderately dense macrophytes (between 30-80% vegetative cover), sex (males prefer <i>Potamogeton</i> spp.)	39; 5

¹ ratings are nil, low, medium or high² complete citations found in the references

Table 29. Vegetation association database – muskellunge.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	submerg		<i>Potamogeton</i> spp.	25;20;21
Strength of Association	high	high		high	1;25;20;21;22
Seasonality Differences					
Factors Affecting Strength				size, larger fish less associated with veg	25

¹ ratings are nil, low, medium or high² complete citations found in the references

Table 30. Vegetation association database – central mudminnow.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg	emerg		cattail, waterweed, eel grass, bullrushes, pondweed, yellow water lily, water buttercup, filamentous algae	1;24;20;21
Strength of Association	high	high		high	38;1;24;25; 20;21;22
Seasonality Differences				inundated terrestrial veg (spring), aquatic macrophytes (summer) and leaf litter (autumn)	24;20;21
Factors Affecting Strength				avoid current	24;20;21

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 31. Vegetation association database – pirate perch.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation					
Strength of Association	nil			high	1;11
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 32. Vegetation association database – brook silverside.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	<i>Scirpus</i> , <i>Potamogeton</i>				38
Strength of Association	high		nil	medium	38;1;15
Seasonality Differences					
Factors Affecting Strength				density, prefers sparse	1

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 33. Vegetation association database – banded killifish.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg, filamentous algae	sub/emerg	macro- phytes	sub/emerg	25;2;20;21;22
Strength of Association	high	high	high	high	38;1;25;17;2;20;21; 22
Seasonality Differences			seasonal growth of macro- phytes		2;20;21;22
Factors Affecting Strength				density, prefers sparse	38;17;1

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 34. Vegetation association database – brook stickleback.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	submerg		submerg	20;21;22
Strength of Association	high	medium		high	1;25;20;21;22
Seasonality Differences					
Factors Affecting Strength				density, prefers moderately dense	1

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 35. Vegetation association database – threespine stickleback.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	submerg		sub/emerg	20;21;22
Strength of Association	low	low		low	20;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 36. Vegetation association database – rock bass.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	macrophytes	rooted macro- phytes			29
Strength of Association	low	high		low	1;25;29, 20;21;42
Seasonality Differences					
Factors Affecting Strength	density - prefers dense macrophytes				29

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 37. Vegetation association database – green sunfish.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	sub/emerg	macro- phytes	emerg	38;25;26;2;20;21;22
Strength of Association¹	high	high	high	high	38;1;25;26;2;20; 21;22
Seasonality Differences			seasonal growth of macro- phytes		2
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 38. Vegetation association database – pumpkinseed.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	macro- phytes	macro- phytes	sub/emerg	38;20;22
Strength of Association¹	high	high	high	high	38;25;20;21;22; 42
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 39. Vegetation association database – smallmouth bass.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	sub/emerg		macro- phytes	sub/emerg	2;22
Strength of Association¹	low	high	high	low	38;1;25;2;22;42
Seasonality Differences		summer	seasonal growth of macro- phytes		2
Factors Affecting Strength	prefers nesting near rocks, logs				38

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 40. Vegetation association database – largemouth bass.

	Spawn/Egg	YOY	Juvenile	Adult	Sources ²
Vegetation	bullrushes, waterlillies	sub/emerg	macro-phytes	sub/emerg including water lillies, cattails, pond weeds	38;25;2;21;22
Strength of Association	medium	high	high	high	38;1;25;37;2;20; 21;22
Seasonality Differences		summer	seasonal growth of macro-phytes		2
Factors Affecting Strength	prefers emergent over submergent				20

¹ ratings are nil, low, medium or high

² complete citations found in the references

Table 41. Vegetation association database – Iowa darter.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	sub/emerg	submerg		rooted veg, filamentous algae	38;1;25;20;21
Strength of Association	medium	medium		high	38;1;25;20;21
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high² complete citations found in the references

Table 42. Vegetation association database – least darter.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation	weeds, filamentous algae	submerg	algae	submerg, filamentous algae, <i>Elodea</i> , <i>Myriophyllum</i> , <i>Ceratophyllum</i> , <i>Potamogeton</i> and other flowering aquatic plants	38;3;1;25;21;22
Strength of Association	high	high	high	high	38;3;1;25;8;20; 21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high² complete citations found in the references

Table 43. Vegetation association database – johnny darter.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation		sub/merg		sub/emerg	21;22
Strength of Association	nil	medium		medium	38;1;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

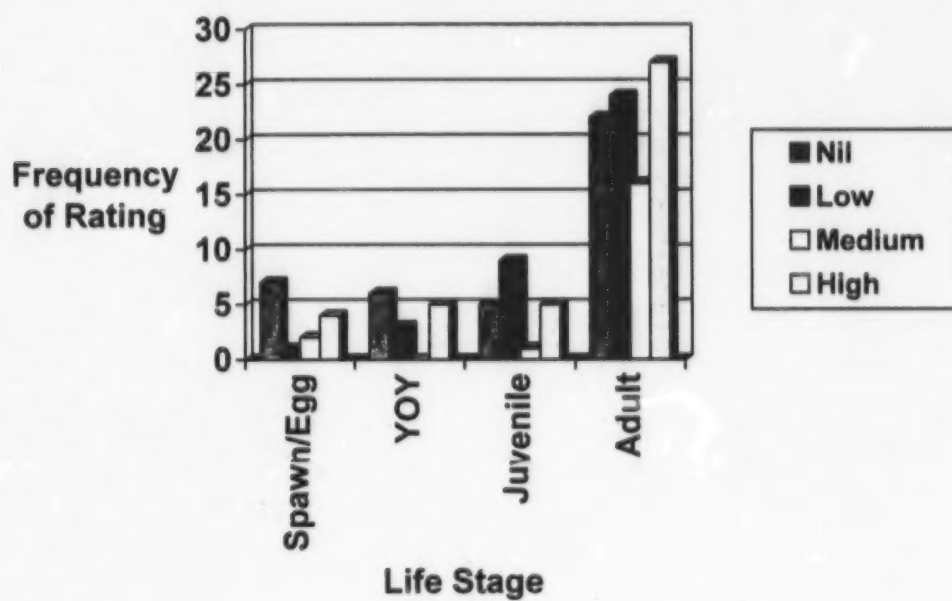
Table 44. Vegetation association database – logperch.

	Spawn/Egg	YOY	Juvenile	Adult	Sources
Vegetation		sub/emerg			21;22
Strength of Association	nil	medium	medium	medium	1;25;21;22
Seasonality Differences					
Factors Affecting Strength					

¹ ratings are nil, low, medium or high

² complete citations found in the references

Figure 1. Frequency of strength of fish-vegetation association ratings by life stage.





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Your file *Votre référence*

Our file *Notre référence*

10 July 2002

Re: Canadian Manuscript Report of Fisheries and Aquatic Sciences #2596

Dear Canadian Manuscript Report of Fisheries and Aquatic Sciences Subscriber,

We have just been made aware that the report bearing the report number of 2596 and titled "Reproductive ecology and vegetation association databases of Lake Ontario fishes" by Becky Cudmore-Vokey and C.K. Minns was assigned the incorrect report number.

The above titled report has now been assigned the report number of 2607.

Please make this change directly to your hard copies (cover page, title page and to page iv) *and* to any entries in databases.

We regret and apologize for any inconvenience. Please feel free to contact either one of us if there are any questions regarding this change.

Regards,

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